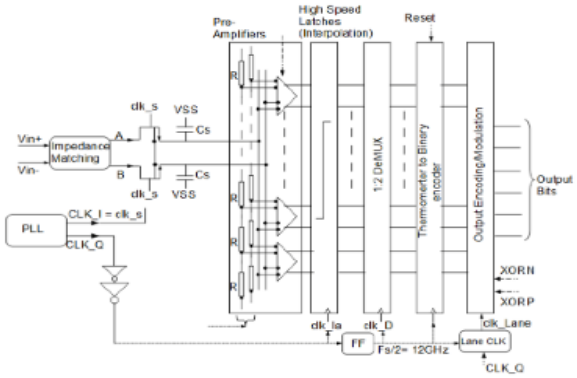
TECHNONOLOGIES UNDER DEVELOPMENT VIA JPL MANAGED PHASE II SBIR, SBIR SELECT & STTR CONTRACTS FOR 2015 – BY SUBTOPIC

- S1.02 Microwave Technologies for Remote Sensing
- S1.03 Sensor and Detector Technology for Visible, IR, Far IR and Submillimeter
- S1.09 Atomic Interferometry
- S2.02 Precision Deployable Optical Structures and Metrology
- S3.01 Power Generation and Conversion
- S3.07 Thermal Control Systems
- S4.02 Robotic Mobility, Manipulation and Sampling
- S4.03 Spacecraft Technology for Sample Return Missions
- S4.04 Extreme Environments Technology
- S5.05 Fault Management Technologies
- H2.01 In-Space Chemical Propulsion
- H9.02 Intelligent Communication Systems
- H9.03 Flight Dynamics and Navigation Technology
- S20.01 Novel Spectroscopy Technology and Instrumentation
- T8.01 Technologies for Planetary Compositional Analysis and Mapping

Microwave Technologies for Remote Sensing

Alphacore, Inc.



Innovation

Design and characterize a 24 Gsps (gigasamples per second), wide input bandwidth (40 GHz), 6-bit (5.0 effective number of bits, ENOB), low-power (700 mW), and low-cost analog-to-digital converter (ADC) for use in a wide range of NASA's microwave sensor remote sensing applications. The ADC provides a very wide spur free input bandwidth making it more suitable to NASA's remote sensing missions and a variety of radio astronomy applications than any other ADC available. The ADC will be radiation hard (>1Mrad) and suitable for use on-board space missions. A key innovation in the approach to the ADC design is a custom designed digital back-end that implements seamless integration with field programmable gate arrays (FPGA) that are the main building blocks of the remote sensing instruments.

Application

Some of the NASA missions that can benefit from the ADC are:
- The Stratospheric Observatory for Infrared Astronomy (SOFIA) Global Atmospheric Composition Mission (GACM)
- Compact Adaptable Microwave Limb Sounder (CAMLS)

Non-NASA Applications
The ADC is a perfect match to a wide range of radio astronomy applications. The ADC also has wide applicability in networking (coherent receivers, network modules), communications (software-defined radio), test equipment (high-speed digital oscilloscopes), radar and electronic warfare (EW) devices. The radiation hardness makes it suitable for commercial and defense sector space applications.

Sensor and Detector Technology for Visible, IR, Far IR and Submillimeter

IntelliEPI IR, Inc.

Innovation

Type II SLS has FPA Applications: High Quantum Efficiency (QE) High pixel yield Low dark current III-V based. Very large format FPA with simple optical coupling. Simplified fabrication. Will leverage commercial III-V foundry for rapid technology development to ensure stable technology platform.

Application

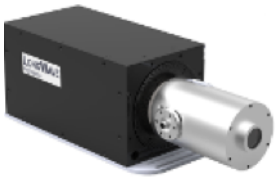
High performance infrared detector materials platform for NASA Earth, planetary science, & astrophysics missions Thermal Infrared Sensor (TIRS) for Landsat satellites

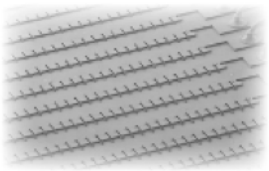
Non-NASA Applications

Defense thermal imaging/night vision/FLIR for vehicles and perimeter surveillance, & missile defense (MDA) Trace chemicals based on sensing unique emission including hyperspectral imaging (CBD). Bio-medical applications such as tumor identification

LongWave Photonics, LLC

Innovation





NASA and NASA funded missions/instruments such as Aura/MLS, SOFIA/GREAT and STO have demonstrated the need for local oscillator (LO) sources between 30 and 300 um (1 and 10 THz). For observations >2 THz, technologically mature microwave sources typically have microwatt power levels which are insufficient to act as LOs for a heterodyne receiver.

Develop a compact, frequency agile, phase/frequency-locked, power stabilized, single mode THz quantum cascade laser system with >2 mW average power output based on LongWave's EasyQCL platform. The source will be frequency agile over a 150 GHz range, with center frequencies ranging from 2 to 5 THz. The laser will be phase/frequency to achieve narrow line widths (<100 kHz) and power stabilized to remove long-term frequency or power drift.

Application

NASA applications include the use of the QCL as an LO for >2 THz receivers for future remote sensing missions. Here the narrow line width (<100 kHz) of the QCLs can be used to resolve Doppler-limited low pressure gasses (~MHz linewidth). The DFB QCL LO would be a frequency agile, compact replacement for any gas-laser LO. This turn-key table-top high power (>2mW) THz source with frequency/power stabilization can provide a platform for developing other key components in the receiver channel.

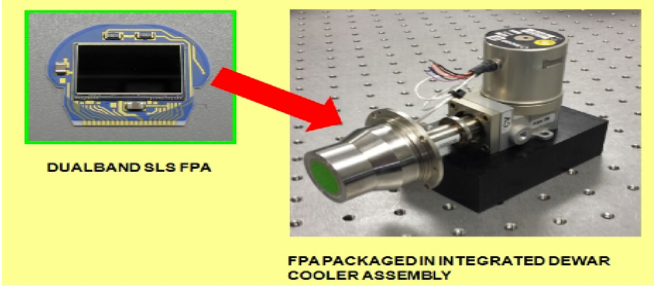
Non-NASA Applications

The QCL has seen increasing needs for local oscillator to perform heterodyne measurement at THz range from non-NASA academic and government researchers. Also the absolute frequency of the laser has uses for researchers in the high-resolution gas spectroscopy field. Long-term applications include industrial uses for trace gas detection and THz detector/imager power calibration.

QmagiQ, LLC

Innovation

1) High-Definition Dualband infrared focal plane array with fire (3-5 micron) and thermal (8-12 micron) imaging channels for sensitive and reliable wildfire detection



2) Dualband sensor = Back-to-back

photodiodes of Ga-free strained layer superlattice (SLS) with high minority carrier lifetime

3) High quantum efficiency expected: QE > 50% (fire channel), > 30% (thermal channel)

4) Dark current and operating temperature (> 77K) comparable to mercury cadmium telluride (MCT)

5) High operating temperature translates to small, light and more reliable cryocooler

6) Cost much lower than MCT

Application

1) Satellite-based wildfire detection
2) Other infrared earth-observing missions like LANDSAT-TIRS, CLARREO and BOREAS
3) Astronomy of distant dim objects (e.g. James Webb Space Telescope, planetary missions)
4) Spectral mapping of vegetation, crops and forest-cover
5) Pollution monitoring and Atmospheric chemistry
6) Thermal mapping of oceans and landmasses

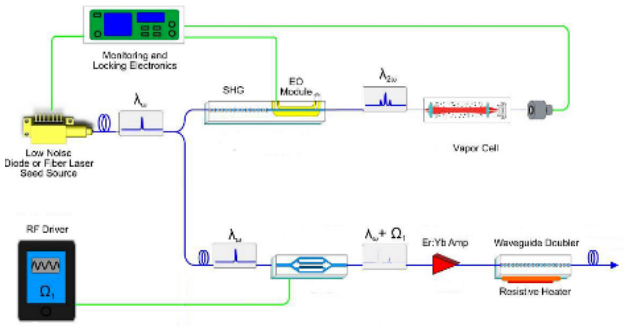
Non-NASA Applications

1) Missile defense 2) Space-based situational awareness 3) Security & surveillance 4) Gas and chemical-vapor imaging 5) Medical imaging 6) Hyperspectral imaging and Imaging spectroscopy

Atomic Interferometry

ADVR, Inc.

Innovation



Develop compact, robust, integrated components suitable for atomic interferometry. The design is enabled by capitalizing on robust, low-noise telecom components with high reliability and declining costs. The key innovation is the combination of current telecom-based fiber laser and modulator technology with periodically-poled waveguide technology to produce tunable laser light at rubidium D1 and D2 wavelengths (and expandable to other alkalis) using second harmonic generation (SHG). Multiple channels can be independently tuned to produce the fields needed for addressing atomic states in atom interferometers and clocks. In addition, this technology could be useful in the development of cold-atom inertial sensors and gyroscopes.

Application

The primary beneficiary of the proposed system is NASA's QSTG and the GSFC team working on atom interferometry. Atom-based inertial sensing and free-space communications are other exciting new technologies that could benefit from highly efficient

frequency conversion devices in this wavelength range. Remote sensing missions like ACE that require such platforms will also benefit.

Non-NASA Applications

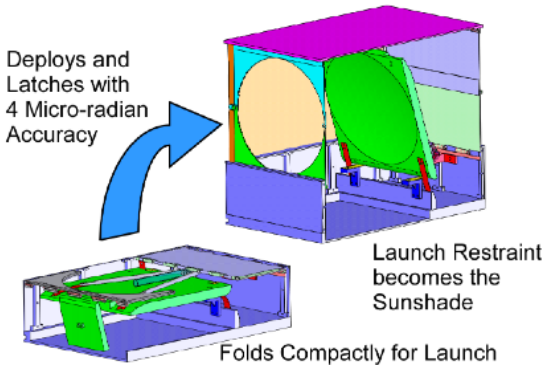
Nonlinear poled materials play an increasingly important role in photonics applications that may be in nonstandard wavelength regions; some of which include microwave photonics, up-conversion, infrared detection, IR generation, and bio- photonics. The technology will be of use for sensing and environmental monitoring, precision spectroscopy, interferometry, and frequency metrology.

Precision Deployable Optical Structures and Metrology

Physical Sciences, Inc.

Innovation

Develop a simple scalable deployable telescope latching technology. The latch was experimentally shown to have better than 350nm repeatability and stability. Also demonstrated was an alternative, locking flexure approach. Both approaches provide a small, low-cost latching system with sub-micron positional repeatability and dynamic stability. This effort will determine the limits of the mechanism and locking flexures and lead to a down-select of one approach for full system development. The effort will integrate the precision motion into a complete, large aperture system for a 6U cubesat telescope. In addition to the precision latching components, the team will also address launch restraint, deployment actuation & rate control, and the associated deployment of the sun shade and light baffles. The results will be an integrated system that will provide all of the systems needed to launch, deploy, and operate high performance optical instruments from small spacecraft platforms.



Application

A family of low-cost but precise latch systems would have application to stellar and planetary observatories as well as atmospheric transmission measurement systems. In addition to data gathering, optical systems are also used for high bandwidth communications. Deployed, large area laser communications optics would increase data throughput from interplanetary missions as well as earth orbiting systems.

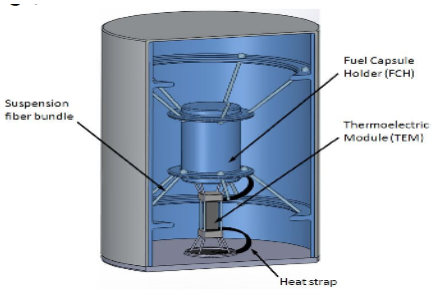
Non-NASA Applications

There are many DoD and IC applications of earth observing telescopes. The proposed latch technology would also apply to rapidly erected telescope systems for ground use, either for observations or for secure laser communications. In addition to government users, there are a wide range of commercial applications for precision restraint of optical components.

Power Generation and Conversion

TECHNOLOGY, Inc.

Innovation



The ability of a 40mW RPS to survive high shock loads up to 10,000G's has been enabled through an innovative means of suspending critical components with the RPS. An improved method of forming reliable and consistent electrical contacts on the thermoelectric module (TEM) has been demonstrated and a method of fabricating a consistent and repeatable TEM bonded with epoxy has been identified that may potentially lead to a stronger and more reliable TEM.

Application

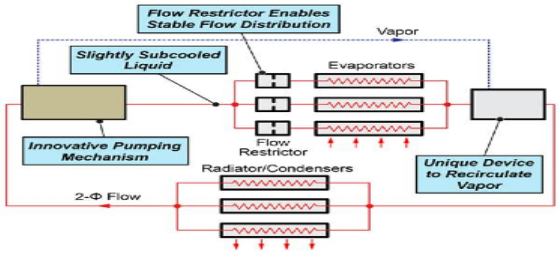
Power supply for (RPS): Penetrator Probes Landers
Instrument surface packages Rover drop off packages on Mars and Europa

Non-NASA Applications Wireless sensors
Energy Harvesting

Thermal Control Systems

Creare LLC

Innovation



Remote sensing science missions need reconfigurable thermal control systems to cool multiple instruments. Highly adaptable and reconfigurable two-phase pumped loop architecture with multiple evaporators and multiple radiators
- Unique mechanism to circulate two-phase flow exiting from radiators
- Stable cooling temperatures for a network of evaporators with variable heat loads
- Unique mechanism to enable reliable pumped loop start-up
- Actively controlled two-phase pressure at evaporator inlet to minimize cooling temperature drift
- Gravity-insensitive components

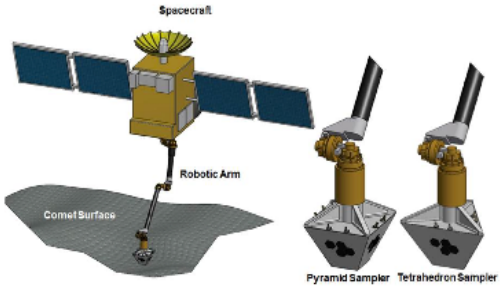
Application

- Thermal control systems for future remote sensing science missions, including Surface Water and Ocean Topography (SWOT)
- Thermal control systems for advanced spacecraft with multiple instruments
Non-NASA Applications
- Two-phase thermal control systems in commercial and military satellites, aircraft, high altitude balloons, and vehicles
- Thermal management systems for high-power electronics systems

Robotic Mobility, Manipulation and Sampling

Honeybee Robotics, Ltd.

Innovation



Asteroids and Comets are considered to be remnants of the processes that formed the Solar System. If we are to acquire a better understanding of the nature, origin, and evolution of comets it will be necessary to bring well preserved samples back. Decadal Survey stated that one of the next New Frontier Mission, NF4, should be Comet Surface Sample Return (CSSR). The report stressed the importance of getting a sample that would retain volatiles and any organic compounds that might be present.

Application

Samples from comets, asteroids and small moons hold great scientific interest. Near term missions that would benefit this technology include NF4 Comet Surface Sample Return and Cryogenic Comet Nucleus Sample Return (CCSNR) Mission. The sampler can also be used on NASA Asteroid Redirect Mission.

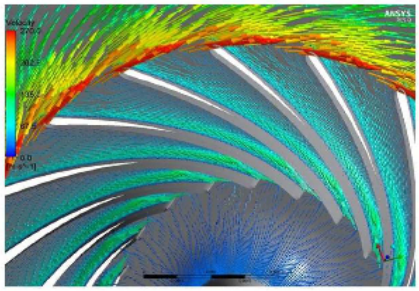
Non-NASA Applications

The sampling probe and canister subsystems for touch and go sampling could be repurposed for capturing of samples from hazardous terrestrial sites (nuclear reactors, chemical spills). The samplers could be deployed from quadcopters. Planetary Resources and Deep Space Industries, companies interested in asteroid mining for economic gains, would benefit these technologies as well.

Spacecraft Technology for Sample Return Missions

Creare LLC

Innovation



The Gas Flow Around the Compressor Impeller Blades Is Modeled in CFD

A key objective for NASA's next rover mission to Mars is the demonstration of oxygen production from atmospheric carbon dioxide. Such a technology demonstration may pave the way for a future sample return mission to Mars, as well as possible future manned missions. A necessary component in such a demonstration system is a blower or compressor that can deliver the necessary carbon dioxide mass flow to a production plant. This proposal is for the development of a radial flow compressor that is capable of a mass flow rate of 400 g/hr. The compressor will be a turbomachine based on a space qualified vacuum pump technology currently operating on the Curiosity rover in Gale Crater on Mars.

Application

The primary application for the compressor proposed is to compress Martian atmospheric carbon dioxide as part of an ISRU plant. The same technology will be applicable for larger production plants for a Mars sample return and an eventual Mars human mission. This space qualified compressor may also have applications for other planetary missions for gas storage and filtration systems.

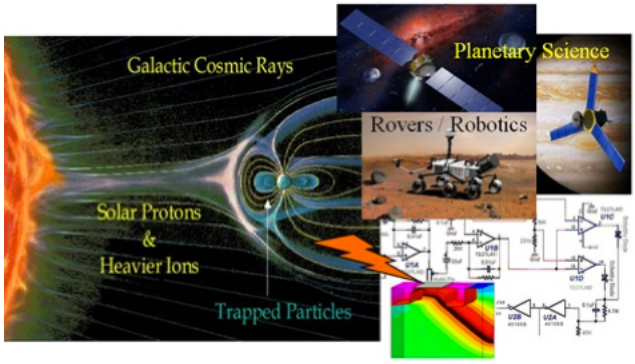
Non-NASA Applications

The potential commercial applications for a small, high efficiency compressors are numerous. This unit will be incorporated in high value analytical instruments for atmospheric sampling and for systems to detect airborne chemical, biological, and nuclear agents.

Extreme Environments Technology

CFD Research Corporation

Innovation



NASA space missions need reliable, low-power, low-noise, RF electronics that can operate over a wide temperature range (wide-T, -230° to +130° C) and high radiation. Silicon-germanium (SiGe) - a robust IC technology with superior electronic properties, resilience to harsh environments, and moderate cost - can dramatically reduce mission size, weight, power and cost. The newest IBM 9HP SiGe platform enables highly integrated (sub) mm-wave applications not possible with earlier SiGe technologies. However, 9HP is yet to be tested in detail for wide-T and radiation effects and few data or simulation models exist.

Innovations: (1) Detailed characterization of best-in-class IBM 9HP SiGe RF electronics for extreme temperatures & transient radiation response. (2) Validated modeling tools for 9HP-based devices/circuits. (3) Novel Rad- Hard designs of mixed-signal/RF circuits, tested for extreme/low temperatures, which will not require Warm Box and will decrease weight/cost of missions.

Application

Radiation-hardened and wide-temperature mixed-signal/RF circuit technology development is aligned with the major flight programs within the Planetary Science Division: Discovery, New Frontiers, Lunar Quest, Mars Exploration, and Outer Planets Programs, including EJSM. Electronics operating in extreme environments without bulky and power inefficient protective shielding and heating/cooling infrastructure will make possible new investigations of the Solar System.

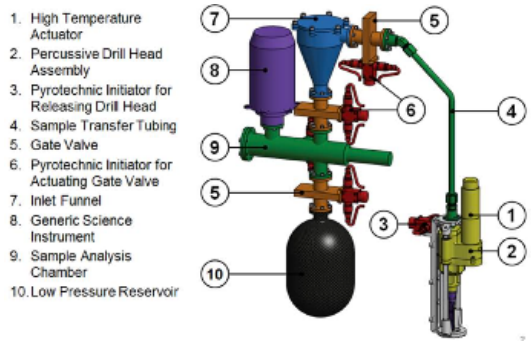
Non-NASA Applications

Various critical analog, mixed-signal, RF, and digital circuits used in all space- based platforms, including DoD space systems (communication, surveillance, ballistic missiles, missile defense), and commercial satellites. Also, cryogenic electronics for high-sensitivity, low-noise analog and mixed-signal applications, such as metrology, infrared (IR) imagers, and sensors.

Honeybee Robotics, Ltd.

Innovation

The recent Planetary Decadal Survey recommended Venus In Situ Explorer (VISE) as one of the 5 candidates for the New Frontiers type mission, since many questions about Venus cannot be addressed by an orbiter. The mission would focus on detailed characterization of the surface and hence it needs a sample acquisition and delivery system.



Application

The HT drill and sample transfer system would be used on the New Frontiers Venus (Venus In Situ Explorer) mission. Missions to other planetary bodies with atmospheres (Titan, Mars) could also benefit this technology.

Non-NASA Applications

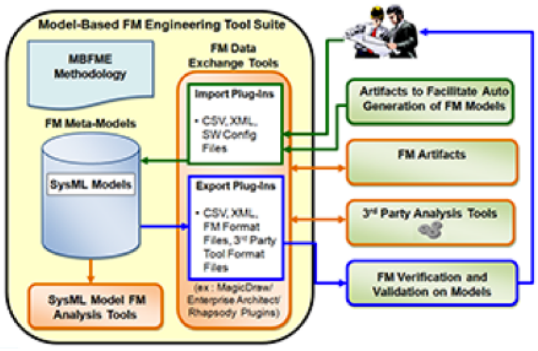
The HT technology is required for geothermal drilling applications as well as in Oil and Gas industry where wells are deeper and in much hotter regions (300° C and more). The small, robust sampling systems could also be used in hazardous locations (e.g. concrete samples from nuclear reactors or soil samples from chemical spills, and volcanoes).

Fault Management Technologies

Tietronix Software, Inc.

Innovation

The proposed innovation is aimed at developing a method and associated tool suite to support Model Based Fault Management Engineering (MBFME) for NASA's next generation space vehicles, habitats, and robotic systems. The concept will enable the integration of fault management early in the system engineering lifecycle, thus facilitating the discovery of design weaknesses and enhancing the capability to produce safe, hazard-free systems.



Application

Human/Robotic missions, Small Pressurized Rovers, Human Exploration Spacecraft Test bed for Advancement and Integration (HESTIA), Cascade Distillation System (CDS) 2.0, Integrated Power and Avionics System (iPAS) test bed, and Europa.

Non-NASA Applications

DoD: UAV, UCAV, ULV, Training Simulators; Commercial: Medical device domain and any complex system using Model Based Engineering and requiring advanced Fault Management.

In-Space Chemical Propulsion

e-beam, Inc.

Innovation

The proposal combines scandate and reservoir cathodes into a hybrid assembly that will provide unprecedented life and performance. The cathodes could be used in high power ion and Hall-effect thrusters. The proposed innovations in the scandate and reservoir cathodes will extend their life and improve their performance. The improvement in the hollow reservoir cathode will lower its temperature to 960° degrees Cb(W) for 20 A/cm2 (temperature-limited) emission. The improvement in scandate cathodes would lower their temperature to 860° degrees Cb(W) for 20 A/cm2 (temperature-limited). 20 A/cm2 translates to about 60 amps of discharge current.

These low temperatures imply a huge improvement in cathode life and stability, but are of little value if the heater-off equilibrium temperature rises to 1200° at high discharge currents (50A or above). At that temperature, cathodes degrade rapidly.

Application

Lunar cargo missions, the JUNO mission to Jupiter, and piloted interplanetary missions become feasible with sufficient cathode output and life. Station-keeping and earth-escape could occur by all-electric means, lowering cost, size and mass. Improved cathodes are needed for microwave amplifiers for space communications, terahertz amplifiers and sources. Scandate cathodes are the key to accessing the region of frequency space that is unutilized because of cathode technology limitations.

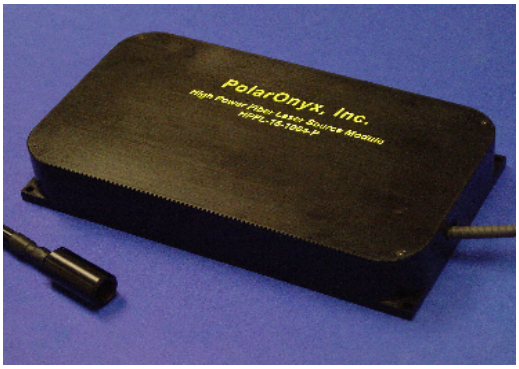
Non-NASA Applications

The cathodes proposed here would increase life, performance, frequency data rates and resolution in radars and communications systems. Other applications: high-speed x-ray tomography, electron beam-stimulated lasers, especially at UV, and geosynchronous satellite downlinks and propulsion systems.

Intelligent Communication Systems

Polaronyx, Inc.

Innovation



High efficiency pulsed lasers have been considered an enabling technology to build high power transmitters for future deep space high rate space communications. To achieve a high peak power at a high repetition rate and with a short pulse width and >25% wall plug efficiency still remains an unsolved issue.

This proposal is for a novel approach to resolve the issues of pulse distortion and nonlinear effects (SBS, SPM, and SRS) and to achieve high efficiency (25%), high power (20 W), high PRR (0.4-400 MHz), high extinction ratio (>33 dB), in collaboration with Lawrence Livermore National Laboratory (LLNL). An unprecedented LMA Er-doped PCF (Yb free) is proposed to resolve the issues of low efficiency pumped at 1530 nm and nonlinear effects.

Application

The proposed short pulse high power fiber laser approach can also be used in other applications, such as space, aircraft, and satellite applications of LADAR systems and communications.

Non-NASA Applications

High power fiber lasers represent the next generation of critical optical components to build the coherent optical communications. Other commercial applications include material processing (e.g., welding, cutting, annealing, and drilling, semiconductor and microelectronics manufacturing, marking) along with medical devices.

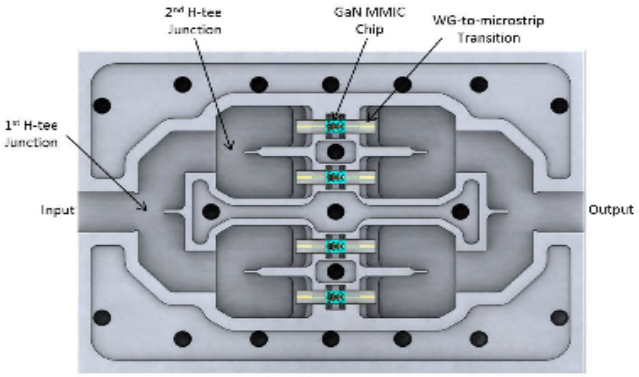
Flight Dynamics and Navigation Technology

Quinstar Technology,Inc

Innovation

1) Future NASA robotic and manned space exploration missions require high-efficiency (60%) solid-state power amplifiers (SSPAs), operating at Ka- band, for high data rate, long range space communications

2) Employing state-of-the-art GaN MMIC technology to fabricate a high- efficiency, SSPA operating at Ka-band frequencies (31.5-34 GHz)



High-Efficiency SSPA
Size: 2.50 x 1.75 x 0.77 inches, Weight: 5 oz.

3) GaN devices are operating in a Class-F switching mode for highest efficiencies; simulations with commercial foundry models show that it is possible to realize power-added efficiency (PAE) levels above 60%

4) Employ a high-efficiency (95%) 4-way planar combiner to achieve 20 W output power.

Application

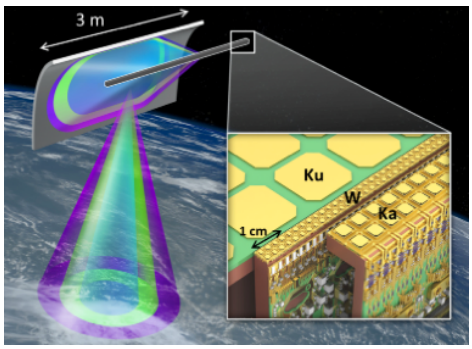
Future NASA robotic and manned space exploration missions require high- efficiency SSPAs, operating at Ka-band, for high data rate, long range space communications. Ka-band is preferred due to bandwidth and EIRP considerations. A key enabler is this high-efficiency SSPA, which can provide efficiency levels 20% to 30% higher than existing technology. Other NASA applications include Ka-band radar sensors for planetary landings and a wide variety of Earth science missions.

Non-NASA Applications

DoD applications include SATCOM in the 29.5-31 GHz band and military radar applications (UAVs and airborne) in the 33-38 GHz band. In the commercial segment, a market exists in SatCom terminals. Additional markets include airborne terminals for commercial airlines, weather and environmental monitoring radars and aircraft landing systems.

Novel Spectroscopy Technology and Instrumentation

Nuvotronics, LLC



Innovation

This proposed program addresses the need for a space-borne phased array radar system that operates simultaneously at multiple frequency bands for future NASA remote sensing missions dedicated to fundamental investigations for aerosols, clouds, air quality and ecosystems. The effort will deliver active, electronically scanned array tiles at Ku- and Ka-bands utilizing the PolyStrata® technology for integration alongside an electronically scanned W-band array to form a tri-band system. The PolyStrata® wafer-scale microfabrication process, with capabilities to monolithically integrate dielectric-free antennas with air-coax feed networks in 3D, is a key enabler for achieving state-of-the art performance requirements and manufacturing scalability. High power levels will be achieved by integrating state-of-the art GaN MMICs into the PolyStrata® front-end architecture.

Application

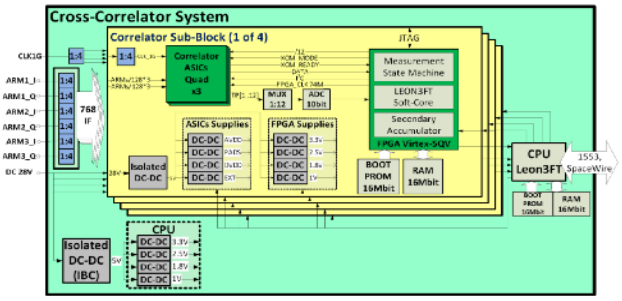
The proposed solution applies to future Earth science remote sensing missions including: Tri-band cloud and precipitation radar systems for Aerosols/Clouds/Ecosystems (ACE) mission and the Cloud and Precipitation Processes Mission (CaPPM) for vision beyond GPM; and the Snow and Cold Land Processes (SCLP) mission. This technology has applications in planetary landing radars (e.g.: what is used for the Mars Science Laboratory mission).

Non-NASA Applications

Microwave and millimeter-wave active electronically scanned radar systems for rotorcraft landing in degraded visual environment (e.g. brown-out conditions); guided missile seekers; non-lethal active denial directive energy systems; unmanned aerial system collision avoidance.

Pacific Microchip Corporation

Innovation



The NASA's PATH mission employs a synthetic aperture radiometer that produces 768 IF (10MHz - 500MHz) signals. Digitizing the signals results in a 1.536Tb/s (1GS/s, 2-bit) data stream. A low power 64x64 cross-correlator ASIC offering has been developed to reduce the amount of data to manageable levels. To ensure further reduction of power consumption and complexity, this ASIC includes an array of 128 digitizers operated at 1GS/s and at 2-bit precision. This ASIC is the key component in the proposed low power cross-correlator system for PATH. The innovation offers to greatly reduce the power consumption, weight and the system's complexity.

Application

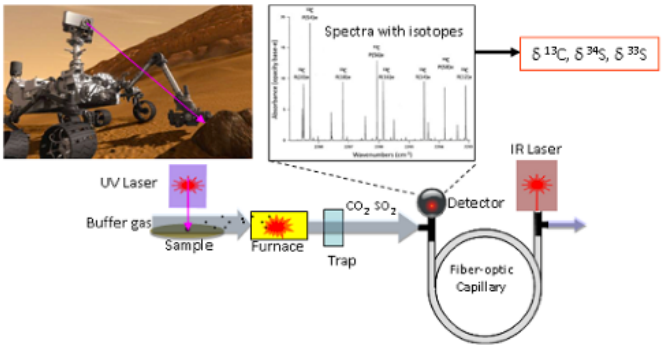
- Synthetic aperture radiometer used for the PATH mission
-Space and land based radiometer and interferometer instruments.

Non-NASA Applications
- Radiometry, interferometry and spectrometry for remote sensing
-Image sensor signal processing -Synthetic aperture radars used in both military and civil aviation
-Future sensor networks.

Technologies for Planetary Compositional Analysis and Mapping

Opto-Knowledge Systems, Inc. (OKSI)

Innovation



The effort will result in the development of a new, innovative sensor platform for isotope and trace-gas analysis. Among other applications, the technology can enable the collection of isotope ratio data in support of the search for evidence of life within the solar system. Current limitations to in-situ isotope measurements will be overcome by utilizing a capillary absorption spectrometer (CAS). This concept enables high

precision measurements within the ultra-small volume (~ 0.1 ml) of a hollow fiber optic capillary and has proven to be three orders of magnitude more sensitive than competing sensors. The sensitivity afforded by the proposed system would open up remote analysis of smaller samples than ever before measured, which could be a significant development in the search for biosignatures on other planets and near space objects, as well as in the early Earth rock record.

Application

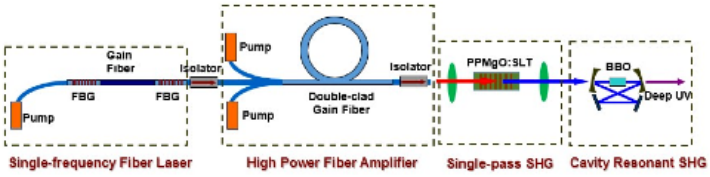
The project will support efforts to search for evidence of life within the solar system. The technology will be useful for planetary missions and in the analysis of primitive meteorites, comets, and interplanetary dust particles, as well as ancient rocks on Earth. Other NASA applications include remote water isotope measurements, atmospheric sensing from a small UAV, analysis of soil bacteria related to the Carbon cycle, and full elemental analysis of microscopic-sized samples and organisms.

Non-NASA Applications

The CAS sensor to be developed under this project will be applicable to niche markets in forensic analysis, environmental sensing, human breath analysis, and industrial process control. The new capabilities and features of the CAS will enable new applications in isotope and gas sensing that simply were not possible before.

TIPD, LLC

Innovation



Deep-ultraviolet (DUV) Raman spectroscopy is a powerful technique to collect specific chemical composition information about complex samples. The innovation is because deep-UV (λ < 250 nm) excitation shows more than a 200-fold greater efficiency compared to commonly applied 785 nm excitation and has the ability to avoid fluorescence background in the Raman spectra. The lack of compact, robust, and reliable deep-UV laser sources has been always considered an obstruction to implementing DUV Raman spectroscopy in NASA's space-borne applications. TIPD will leverage substantial experience and capability in the design and fabrication of single-frequency fiber lasers and deep UV laser development to build an ultra-stable, compact, and robust deep-UV laser source that will enable space-borne Raman spectroscopy measurements. A >100mW at 244nm laser system will have the following advantages: ultrastable performance, very narrow linewidth, compactness, power scalability, and upgradability.

Application

Deep-UV Raman spectroscopy is a powerful tool to identify a variety of gas, liquid, and solid materials critical to understanding the evolution of the solar system and the universe. Compact and ultrastable DUV laser sources can be used for analysis of geological and mineralogical planetary composition, planetary habitability assessment, and for the search of past life on Mars, and for human protection in space.

Non-NASA Applications

Deep UV sources can be broadly used for Raman spectroscopy, laser cooling and trapping, laser inspection, optical data storage, metrology, biomedical applications, and laser lithography. The 488 nm blue laser, which is part of 244 nm system, has potential applications in submarine imaging, sensing, communications, data storage, undersea oil exploration, and medicine.